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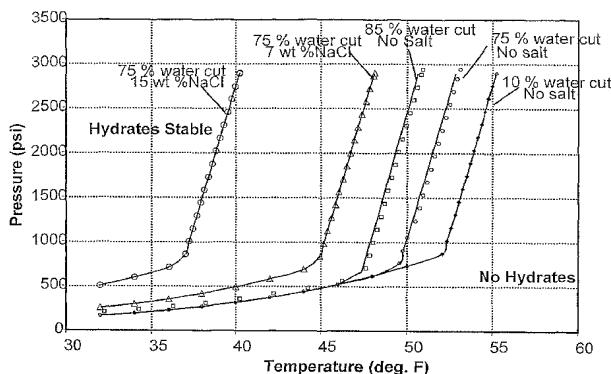
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[Continued on next page]

(54) Title: METHOD AND SYSTEM FOR PREVENTING CLATHRATE HYDRATE BLOCKAGE FORMATION IN FLOW LINES BY ENHANCING WATER CUT



(57) Abstract: The present invention includes a method for inhibiting hydrate formation blockage in a flow line used to transport hydrocarbon containing fluids. Water is added to a hydrocarbon containing fluid to produce a water cut enhanced hydrocarbon containing fluid. Salt may be added to the hydrocarbon containing fluids as well. Hydrate formation blockage is inhibited from forming within the flow line by the addition of the water and/or the salt. Sufficient water may be added such that the hydrocarbon containing fluid is converted from a water in oil emulsion to a water continuous emulsion. A system for preventing the formation of hydrate blockage in conduits is also provided. The system includes a flow line for transporting a hydrocarbon containing fluid and a water injection conduit fluidly connected to the flow line to add water to the flow line to increase the water cut of a hydrocarbon containing fluid flowing through the flow line. A salt dispenser may also be included which is used to increase the salinity of the hydrocarbon containing fluid. The system may further include a water separator to separate hydrocarbons from water which receives fluids from the flow line. The flow line, water separator and water injection conduit may cooperate to form a loop wherein water from the flow line may be separated by the water separator and a portion of the separated water is delivered back to the water injection conduit to be reinjected into the flow line.



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1       **METHOD AND SYSTEM FOR PREVENTING CLATHRATE HYDRATE**  
2       **BLOCKAGE FORMATION IN FLOW LINES BY ENHANCING WATER CUT**

3  
4                               TECHNICAL FIELD

5  
6       The present invention relates to preventing the formation of clathrate hydrate  
7       blockages in flow lines or conduits carrying hydrocarbons.

8  
9                               BACKGROUND OF THE INVENTION

10  
11       Clathrate hydrate plug formation in oil and gas pipelines is a severe problem for  
12       the petroleum industry. When water is produced along with gas, oil, or mixtures  
13       of both, under the right pressure and temperature conditions, there is a  
14       potential to form a solid hydrate phase. Pressure-temperature conditions  
15       favorable for hydrate formation are commonly encountered during the winter in  
16       fields onshore and in shallow water depths offshore, and regularly in deepwater  
17       (>1,500 feet water depth) fields offshore. As a rule of thumb, at a seafloor  
18       temperature of about 40°F for water depths greater than 3,000 feet, hydrates  
19       can form in a typical natural gas pipeline at pressures as low as 250 psi. As  
20       solid hydrates form, the hydrates can deposit on the pipe walls or agglomerate  
21       into larger solid masses creating obstructions to flow.

22  
23       Technologies currently used to prevent hydrate blockage formation include  
24       dehydration, heat and/or pressure management or chemical injection with  
25       thermodynamic or low dosage hydrate inhibitors (LDHI). Dehydration is simply  
26       removing most of the water from the hydrocarbon stream so that too little is left  
27       to form hydrate blockages. Temperature or pressure control is used to operate  
28       a system outside of conditions that can promote hydrate formation. The  
29       addition of thermodynamic inhibitors (typically alcohols, glycols or salts)  
30       produces an anti-freeze like effect that shifts the hydrate phase equilibrium  
31       condition to lower temperatures at a given pressure so that a system may be  
32       operated safely outside the hydrate stability region. LDHI act in one of two  
33       ways: 1) as a kinetic inhibitor, or 2) as an anti-agglomerant. Kinetic LDHIs

1 merely slow the hydrate formation rate so that formation of a solid blockage is  
2 retarded during the residence time of the fluids in the pipeline. Anti-  
3 agglomerant LDHIs allow the hydrates to form, but keep the hydrate particles  
4 dispersed in a liquid hydrocarbon phase. Anti-agglomerant LDHIs are also  
5 known to have limitations on the water cut in which the chemicals can work.  
6 They are usually recommended for application for water cuts of less than 50%.

7  
8 Each of these solutions for hydrate prevention can work, but all require  
9 significant capital or operating expense. The thermal and dehydration options  
10 are capital intensive, the thermodynamic inhibitor options are both capital and  
11 operationally intensive, and the LDHI option is operationally intensive. LDHIs  
12 also have additional risk associated with their application due to the relative  
13 immaturity of the technology. Additionally, discharge water quality (toxicity) and  
14 crude quality (methanol content for example) issues can be a concern when  
15 using both thermodynamic inhibitors and LDHIs. There is also a general  
16 concern in the industry that as remote deepwater fields mature, water cuts may  
17 become high to the point where chemical injection for hydrate inhibition may  
18 offer considerable challenges – either due to the sheer volumes of  
19 thermodynamic inhibitor required or due to limitations on LDHI performance as  
20 mentioned above. Therefore, the issue of a cost-effective and reliable hydrate  
21 inhibition strategy for fields with high water cuts is a major challenge facing the  
22 industry.

23  
24 There are additional flow assurance issues commonly found with low-  
25 temperature high pressure flow in flow lines. In cases where there is water in  
26 an oil emulsion, such an emulsion can have high viscosity leading to problems  
27 associated with excessive pressure drop. The present invention, to be  
28 described hereafter, addresses the challenges described above.

## 29 30 SUMMARY OF THE INVENTION

31  
32 The present invention includes a method for inhibiting hydrate formation  
33 blockage in flow lines used to transport hydrocarbon containing fluids. Water

1 is added to a hydrocarbon containing fluid to produce a water cut enhanced  
2 hydrocarbon containing fluid. The water cut enhanced hydrocarbon  
3 containing fluid is then transported by a flow line. Hydrate formation blockage  
4 is inhibited from forming within the flow line by the addition of the water which  
5 tends to lower the hydrate phase equilibrium temperature for a given pressure  
6 of the hydrocarbon containing fluid and flow velocity.

7  
8 Preferably, the resulting water cut enhanced hydrocarbon containing fluid is  
9 water continuous. Sufficient water may be added such that the hydrocarbon  
10 containing fluid is inverted from a water in oil emulsion to a water continuous  
11 emulsion state thereby decreasing emulsion viscosity and reducing pressure  
12 drop in the flow line.

13  
14 Sufficient water may be added such that the water cut of the water cut  
15 enhanced hydrocarbon containing fluid is at least 50%, and possibly even  
16 75% or 85%. The hydrate thermal equilibrium temperature of the water cut  
17 enhanced hydrocarbon containing fluid may be lowered 2.5°F, 5.0°F, or even  
18 10°F as compared to the original hydrocarbon containing fluid.

19  
20 Further, sufficient water may be added to the original hydrocarbon containing  
21 fluid such that there is an excess of the water phase relative to the hydrocarbon  
22 phase such that hydrate formation is self limiting. This occurs when the  
23 hydrocarbon hydrate forming components are exhausted through hydrate  
24 formation and a flowing slurry of hydrates, hydrocarbons and water results.

25  
26 Salt may be added to increase the salinity of the water cut enhanced  
27 hydrocarbon containing fluid. The weight % of salt in the water cut enhanced  
28 hydrocarbon containing fluid may be 5%, 10% or even 15% or higher.

29  
30 A system for preventing the formation of hydrate blockage in flow lines is also  
31 provided. The system includes a flow line for transporting a hydrocarbon  
32 containing fluid and a water injection conduit fluidly connected to the flow line  
33 to add water to the flow line to increase the water cut of the fluid flowing

1 through the flow line. The flow line should be connected to a hydrocarbon  
2 source and the water injection conduit fluidly connected to a water source.  
3 The system may be operable in an environment sufficiently cool such that  
4 hydrate blockage might form absent the addition of water to the hydrocarbon  
5 containing fluid from the water injection conduit. The hydrocarbon source  
6 may be a well bore from which hydrocarbons are produced. The water source  
7 may sea water, a sub sea water well or a water storage tank mounted on an  
8 offshore platform. Alternatively, the system may be used on land where  
9 hydrocarbon containing fluids are to be transported in flow lines and the flow  
10 lines are exposed to cold temperatures.

11  
12 The system may further include a water separator to separate water from  
13 hydrocarbons received from the flow line. The flow line, water separator and  
14 water injection conduit may cooperate to form a partially closed loop wherein  
15 water from the flow line may be separated by the water separator and  
16 delivered back to the water injection conduit to be reinjected into the flow line  
17 to enhance the water cut of the hydrocarbon containing fluid.

18  
19 It is an object of the present invention to provide a method and system to  
20 address multiple flow assurance issues (hydrate inhibition, emulsion  
21 viscosity/stability, system thermal performance, and system hydraulic  
22 performance) through a simple, cost-effective, and environmentally friendly  
23 strategy.

24  
25 It is another object to provide a method for multiphase production of crude oil  
26 and natural gas wherein hydrocarbon containing fluids are transported through  
27 a flow line at unconventionally high water cuts to thereby reduce hydrate  
28 blockages in the flow line relative to using hydrocarbon containing fluids having  
29 a lower water cut.

1                                    BRIEF DESCRIPTION OF THE DRAWINGS

2

3    These and other objects, features and advantages of the present invention  
4    will become better understood with regard to the following description,  
5    pending claims and accompanying drawings where:

6

7    FIG. 1 is a graph showing the thermodynamic effect of water cut and brine  
8    salinity on the hydrate stability region of a heavy oil;

9

10   FIG. 2 is a graph showing the general change in viscosity of emulsions as a  
11   function of water cut;

12

13   FIG. 3 is a first embodiment of a hydrate blockage inhibiting system which  
14   includes a water injection conduit which injects water and/or salt into a sub sea  
15   wellhead tree to enhance the water cut of a hydrocarbon containing fluid carried  
16   by a flow line to a floating platform in a sea;

17

18   FIG. 4 is a second embodiment of a hydrate blockage inhibiting system which  
19   includes water injection into a sub sea manifold;

20

21   FIG. 5 is a third embodiment of a hydrate blockage inhibiting system which  
22   includes water injection at a riser base;

23

24   FIG. 6 is a fourth embodiment of a hydrate blockage inhibiting system using a  
25   submersible pump to inject sea water into a wellhead tree;

26

27   FIG. 7 is a fifth embodiment of a hydrate blockage inhibiting system using a  
28   submersible pump to inject sea water into a sub sea manifold; and

1 FIG. 8 is a sixth embodiment of a hydrate blockage inhibiting system which  
2 injects water from a sub sea well into a production fluid collected from a fresh  
3 water sub sea well.

4

5 BEST MODE(S) FOR CARRYING OUT THE INVENTION

6

7 The present invention is counterintuitive and surprising in that it calls for adding  
8 excess water to a hydrocarbon containing fluid to inhibit hydrate blockage  
9 formations in flow lines of a system. Conventional wisdom is to remove water  
10 and/or add chemical hydrate inhibitors. This process of purposely adding  
11 water, which is abundantly available in offshore operations, may be a cost-  
12 effective, reliable hydrate blockage inhibition strategy with several potential  
13 additional side benefits. The present invention may also be used on land as  
14 well to inhibit hydrate formation blockages where hydrocarbon containing fluids  
15 are transported along a flow line exposed to cold temperatures.

16

17 This invention applies to multiphase flow systems where formation of hydrate  
18 plugs or other significant hydrate obstructions in flow lines are a concern.  
19 Ideally, water, and possibly salt or brine, is added to a hydrocarbon containing  
20 fluid such that a water continuous phase is present (high water cut). The  
21 addition of the water and salt to the hydrocarbon containing fluid ideally  
22 addresses multiple flow assurance issues (hydrate inhibition, emulsion  
23 viscosity/stability, system thermal performance, and system hydraulic  
24 performance) through a simple, cost-effective, and environmentally friendly  
25 strategy.

26

27 Following this strategy, injection of water could be used to operate systems in a  
28 water continuous emulsion state, thereby decreasing emulsion viscosity and  
29 reducing pressure drops in pipe lines or flow lines. This could be beneficial  
30 especially for heavy oils that may be prone to forming high viscosity water in oil  
31 emulsions at cold sub sea conditions. Further, if a high salinity brine is injected  
32 instead of fresh water, separation problems topside due to emulsions could be



1 potentially alleviated, or at least reduced, since salt can have an emulsion  
2 breaking effect depending on the characteristics of the emulsion.

3  
4 Recent evidence discovered through experiments and modeling with heavy oils  
5 (~20°API) suggests that hydrate equilibrium temperatures are reduced as water  
6 cut increases. The term "hydrate equilibrium temperature" means the  
7 temperature at which hydrates will readily form for a given composition of a  
8 hydrocarbon containing fluid at a particular pressure and flow rate. The effect  
9 of increasing water cut to lower hydrate equilibrium temperature can be found  
10 in most hydrocarbon systems and is unique for each particular composition of  
11 hydrocarbon containing fluid. For example, compositions may contain mostly  
12 natural gas or else predominantly heavy oils. The effect is more pronounced  
13 for heavy oils which tend to have low GORs (gas-to-oil ratio) and low bubble  
14 points.

15  
16 FIG. 1 shows the thermodynamic effect of water cut and brine salinity on the  
17 hydrate stability region of a heavy oil (~20°API). In this example, increasing the  
18 water cut (no salt present) from 10% to 75% reduces hydrate equilibrium  
19 temperature at pressures above the bubble point by approximately 2.5°F;  
20 increasing the water cut from 75% to 85% reduces the hydrate equilibrium  
21 temperature by another 2.2°F.

22  
23 Also, illustrated is the enhanced thermodynamic effect achieved by adding  
24 brine instead of fresh water to lower the thermal equilibrium temperature. For  
25 the heavy oil, increasing the water cut from 10% to 75% by adding brine with  
26 7 weight % NaCl, as opposed to water with no salt, reduces hydrate equilibrium  
27 temperature above the bubble point by 7°F compared to 2.5°F when adding  
28 fresh water only. Adding brine with 15 weight % NaCl reduces the hydrate  
29 equilibrium temperature above the bubble point by 15°F compared to the  
30 10% water cut, fresh water case.

31  
32 FIG. 2 shows a general change in viscosity of emulsions as a function of water  
33 cut. As water cut is increased, a water in oil emulsion can be converted to an

1 oil in water emulsion. The graph shows that viscosity of a water in oil emulsion  
2 is usually considerably higher than that of an oil in water emulsion at high water  
3 cuts (> than 70% water cut). This is especially pronounced in case of heavy oil  
4 systems. At water cuts as high as 90%, viscosity is close to that of water.

5  
6 In addition to the above thermodynamic effect, it is anticipated that by having an  
7 excess of the water phase relative to the hydrocarbon phase in these high  
8 water fraction systems, any hydrate formation reaction would be self limiting as  
9 hydrate forming components (lighter hydrocarbons) in the flow stream are  
10 exhausted. The result is expected to be an oil and hydrate in water slurry.  
11 Within certain operating conditions of fluid flow velocity, system geometry,  
12 water cut, and temperature and pressure the oil and hydrate in water slurry  
13 should remain flowable.

14  
15 As already mentioned, brine also enhances the thermodynamic effect on  
16 hydrate stability produced by adding water to the system. Water also improves  
17 heat retention thereby improving thermal performance of the system which  
18 might be helpful for mitigating certain flow assurance issues. Switching to  
19 water or high salinity brine injection as the hydrate inhibition strategy is also  
20 expected to reduce chemical inhibitor presence in water and the oil phase.  
21 This will have significant benefits for topside water clean up and should result in  
22 reduced penalties imposed on an operator by downstream refineries due to the  
23 elimination of methanol from crude oil. Therefore, the proposed strategy is also  
24 a more environmentally friendly hydrate inhibition strategy as compared to the  
25 current thermodynamic and/or LDHI inhibitor injection strategy since storage,  
26 handling, and processing of flammable (methanol), potentially toxic  
27 (anti-agglomerant LDHIs) chemicals can be eliminated from offshore  
28 operations.

29  
30 FIG. 3 illustrates a first exemplary embodiment of a hydrate blockage inhibition  
31 system 20 which is constructed in accordance with the present invention. An  
32 offshore platform 22 is located in a sea 24 disposed above a sea floor 26. A  
33 well bore 30 is located in a sub sea formation 32. Perforations 34 in well bore

1 30 allow hydrocarbon containing fluids to be extracted from formation 32.  
2 Located atop well bore 30 is a sub sea tree 36. Tree 36 passes a hydrocarbon  
3 containing fluid from well bore 30 to a production flow line or pipeline 40. A sub  
4 sea manifold 42 is disposed intermediate tree 36 and platform 22.

5

6 Platform 22 supports a separator 44 which separates water from the  
7 hydrocarbon containing fluid received from flow line 40. The separated water  
8 may be disposed of in conventional fashions such as dumping the water into  
9 sea 24 after being cleaned to an environmentally acceptable quality.

10 Alternatively, a substantial portion of the separated water or brine solution may  
11 be directed to a water injection flow line 46 which supplies water to be added to  
12 the hydrocarbon containing fluid received from well bore 30. In this instance,  
13 the added water is injected into a port (not shown) plumbed into tree 36.

14 Separated oil exits from separator 44 through an oil discharge line 48.

15 Although, not shown, a separate gas discharge line may also be employed  
16 when substantial amounts of gas are produced and are separated by separator  
17 44.

18

19 A meter 50 measures and controls the quantity of water which is being passed  
20 from separator 44 to a pump 52. Pump 52 is used to increase pressure in the  
21 water passing through water injection conduit 46 and which is injected into the  
22 produced hydrocarbons from well bore 30. Salt may also be added to water  
23 injection flow line 46 from a salt dispenser 53, preferably as a brine such as a  
24 sodium chloride in water solution. In this exemplary embodiment, the water is  
25 injected into tree 36. A water conduit 54 connects separator 44 and pump 52.

26 A water discharge conduit 56 is used to discharge surplus separated water  
27 which is not to be reinjected to enhance the water cut of the produced  
28 hydrocarbon containing fluid from well bore 30.

29

30 The produced hydrocarbon containing fluid from well bore 30 typically arrives at  
31 tree 36 from well bore 30 at a particular pressure and at a temperature which is  
32 significantly above the temperature suitable for hydrate formation. However, as  
33 the produced fluid travels to sub sea manifold 42 and up production flow line

1 40, the cold sea waters surrounding flow line 40 may cool the produced  
2 hydrocarbon containing fluid sufficiently that hydrate formation blockage may  
3 be a significant possibility. That is, the production hydrocarbon containing fluids  
4 may enter into the hydrate stability region for the particular composition of oil,  
5 gas, water, and other constituents of the produced fluids from well bore 30.

6  
7 In operation, the amount of water/brine solution added to the produced  
8 hydrocarbon containing fluid is dependent on the desired characteristics of the  
9 water cut enhanced hydrocarbon containing fluid. For example, if the produced  
10 hydrocarbon containing fluid from well bore 30 is at a low water cut, i.e., the  
11 produced fluid is an oil emulsion containing water or has a hydrocarbon  
12 continuous phase, then sufficient water/brine solution may be added to invert  
13 the fluid into a water continuous, water cut enhanced hydrocarbon containing  
14 fluid. This addition of water may be sufficient to drop the hydrate equilibrium  
15 temperature 2.5°F, 5.0°F, 10°F or even 15°F, depending on how much water  
16 and salt is added to the production fluids being injected into tree 36. Also, it  
17 may be permissible to allow hydrate formation to readily occur if sufficient water  
18 and salt are added to maintain the water cut enhanced production fluid in a  
19 slurry state where individual hydrate particles are suspended in a water  
20 continuous fluid. Accordingly, blockages formed by hydrates will be avoided in  
21 production pipeline 40 which might otherwise occur absent the addition of the  
22 water and/or brine to the produced fluids from well bore 30.

23  
24 FIG. 4 shows a second exemplary embodiment of a system 120 which is similar  
25 to that of the first embodiment shown in FIG. 1. Like components of the system  
26 have been given the same reference numerals as in the first embodiment. In  
27 this instance, the added water/salt is added downstream of the tree 36 with  
28 injection occurring into sub sea manifold 42.

29  
30 FIG. 5 shows a third embodiment of a system 220 wherein water/salt is injected  
31 downstream of tree 36 and sub sea manifold 42 directly into the production  
32 pipeline at the base of a riser. The added water/salt should be injected into  
33 production pipeline sufficiently upstream of where the cold sea water could

1 potentially drop the temperature of the production fluid to where hydrate phase  
2 stability conditions may exist. Accordingly, the beneficial effects provided by  
3 the introduction of added water and salt should be obtained before hydrate  
4 formation blockage can occur.

5  
6 FIGS. 6 and 7 show respective systems 320 and 420 wherein a submersible  
7 pump 60 gathers sea water and adds the extra water to production fluids to  
8 inhibit hydrate formation blockage. In system 320, the extra water is added to  
9 tree 36. In system 420, the extra water is added into the sub sea manifold 42.  
10 The advantage of using these systems 320 and 420 is that no lengthy water  
11 injection flow line 46 need be run from platform 22 to sea floor 26. A  
12 disadvantage is that additional amounts of water separated by separator 44  
13 must be disposed because no water is reinjected into flow line 40.

14  
15 FIG. 8 shows a system 520 wherein fresh water is injected into the production  
16 flow line 40. Production fluids from well bore 30 are collected by sub sea  
17 manifold 42. In this exemplary embodiment, a water well 62 is drilled into the  
18 sub sea formation 64 to provide a source of water. A well head 66 controls flow  
19 from well 62. Preferably, the source of water is fresh water having little brine.  
20 The water then can be added to the production fluid anywhere from  
21 downstream of the production zone, i.e. where perforations 34 are located to  
22 just upstream of where there is a significant potential for hydrate formation  
23 blockage to occur. In this particular exemplary embodiment, the added water is  
24 plumbed into sub sea manifold 42. Although not shown, a subset salt  
25 dispenser could also be used in embodiments 320, 420 and 520 if so desired to  
26 enhance the salinity of the water cut enhanced hydrocarbon containing fluids.

27  
28 In a manner similar to that described above, the present invention could be  
29 used to add water to hydrocarbon containing fluids flowing in pipelines on land  
30 or elsewhere where hydrate formation blockage is a concern. For example, the  
31 pipeline may be operating in a cold and harsh environment such as in Alaska or  
32 Canada where plugging of pipelines and other conduits with hydrate formations  
33 is problematic.

1 In summary, this invention calls for multiphase production of crude oil and  
2 natural gas at high water cuts, possibly adding water/brine to forcibly push a  
3 flow system to higher water cuts. It is expected this strategy will allow  
4 operators to address multiple flow assurance issues (hydrate inhibition,  
5 emulsion viscosity/stability, system thermal performance, and system hydraulic  
6 performance) through a simple, cost-effective, environmentally friendly strategy.  
7

8 While in the foregoing specification this invention has been described in relation  
9 to certain preferred embodiments thereof, and many details have been set forth  
10 for purpose of illustration, it will be apparent to those skilled in the art that the  
11 invention is susceptible to alteration and that certain other details described  
12 herein can vary considerably without departing from the basic principles of the  
13 invention.

1   WHAT IS CLAIMED IS:

2

3   1.    A method for inhibiting hydrate formation blockage in a flow line  
4        transporting a hydrocarbon containing fluid, the method comprising:

5

6        adding water to a hydrocarbon containing fluid to produce a water cut  
7        enhanced hydrocarbon containing fluid; and

8

9        transporting the water cut enhanced hydrocarbon containing fluid  
10       through a flow line under conditions that would be conducive for the  
11       formation of hydrates in the original hydrocarbon containing fluid;

12

13       whereby hydrate formation blockage is inhibited from forming within the  
14       flow line by the addition of the water.

15

16   2.    The method of claim 1 wherein:

17

18       sufficient water is added such that the water cut of the water cut  
19       enhanced hydrocarbon containing fluid is at least 50%.

20

21   3.    The method of claim 1 wherein:

22

23       sufficient water is added such that the water cut of the water cut  
24       enhanced hydrocarbon containing fluid is at least 75%.

25

26   4.    The method of claim 1 wherein:

27

28       sufficient water is added such that the water cut of the water cut  
29       enhanced hydrocarbon containing fluid is at least 85%.

1     5.     The method of claim 1 wherein:

2

3           sufficient water is added to lower the hydrate equilibrium temperature of  
4           the water cut enhanced hydrocarbon containing fluid by at least 2°F  
5           relative to the original hydrocarbon containing fluid.

6

7     6.     The method of claim 1 wherein:

8

9           sufficient water is added to lower the hydrate equilibrium temperature of  
10          the water cut enhanced hydrocarbon containing fluid by at least 5°F  
11          relative to the original hydrocarbon containing fluid.

12

13    7.     The method of claim 1 wherein:

14

15          salt is added to the water to increase the salinity of the water cut  
16          enhanced hydrocarbon containing fluid.

17

18    8.     The method of claim 7 wherein:

19

20          the weight % of salt in the water cut enhanced hydrocarbon containing  
21          fluid is at least 5%.

22

23    9.     The method of claim 7 wherein:

24

25          the weight % of the salt in the water cut enhanced hydrocarbon  
26          containing fluid is at least 10%.

27

28    10.    The method of claim 7 wherein:

29

30          the water phase of the water cut enhanced hydrocarbon containing  
31          fluid is continuous; and



1 the water cut enhanced hydrocarbon containing fluid has a weight % of  
2 salt of at least 5%.

3

4 11. The method of claim 1 wherein:

5

6 the water is added to the hydrocarbon containing fluid at a sub sea  
7 location.

8

9 12. The method of claim 1 wherein:

10

11 sufficient water is added such that hydrate formation is self limiting as  
12 hydrocarbon hydrate forming components in the water cut enhanced  
13 hydrocarbon containing fluid are exhausted through the formation of  
14 hydrate particles.

15

16 13. The method of claim 1 wherein:

17

18 sufficient water is added such that the hydrocarbon containing fluid is  
19 converted from an water in oil emulsion to a water continuous emulsion  
20 thereby decreasing emulsion viscosity and reducing pressure drop in the  
21 flow line.

22

23 14. A system for preventing the formation of hydrate blockage in a flow  
24 line, the system comprising:

25

26 a flow line for transporting a hydrocarbon containing fluid;

27

28 a water injection conduit fluidly connected to the flow line to add water  
29 to the flow line; and

30

31 a hydrocarbon source which is in fluid communication with the flow line  
32 to provide a hydrocarbon containing fluid to the flow line;

1 wherein water may be added to the flow line from the water injection  
2 conduit to enhance the water cut of the hydrocarbon containing fluid.

3

4 15. The system of claim 14 wherein:

5

6 the hydrocarbon source is a well bore.

7

8 16. The system of claim 14 further comprising:

9

10 a water source fluidly connected to the water injection conduit; and  
11 the water source is one of sea water, a sub sea water well or a water  
12 source mounted on an offshore platform.

13

14 17. The system of claim 14 further comprising:

15

16 a water separator fluidly connected to the flow line to receive fluids  
17 containing hydrocarbons and water, the water separator being capable  
18 of separating water from hydrocarbons.

19

20 18. The system of claim 17 wherein:

21

22 the flow line, water separator and water injection conduit cooperate to  
23 form a loop wherein water from the flow line may be separated by the  
24 water separator and delivered back to the water injection conduit to be  
25 reinjected into the flow line.

26

27 19. The system of claim 14 further comprising:

28

29 a salt dispenser which connects relative to the flow line so that salt may  
30 be added to increase the salinity of the hydrocarbon containing fluid.

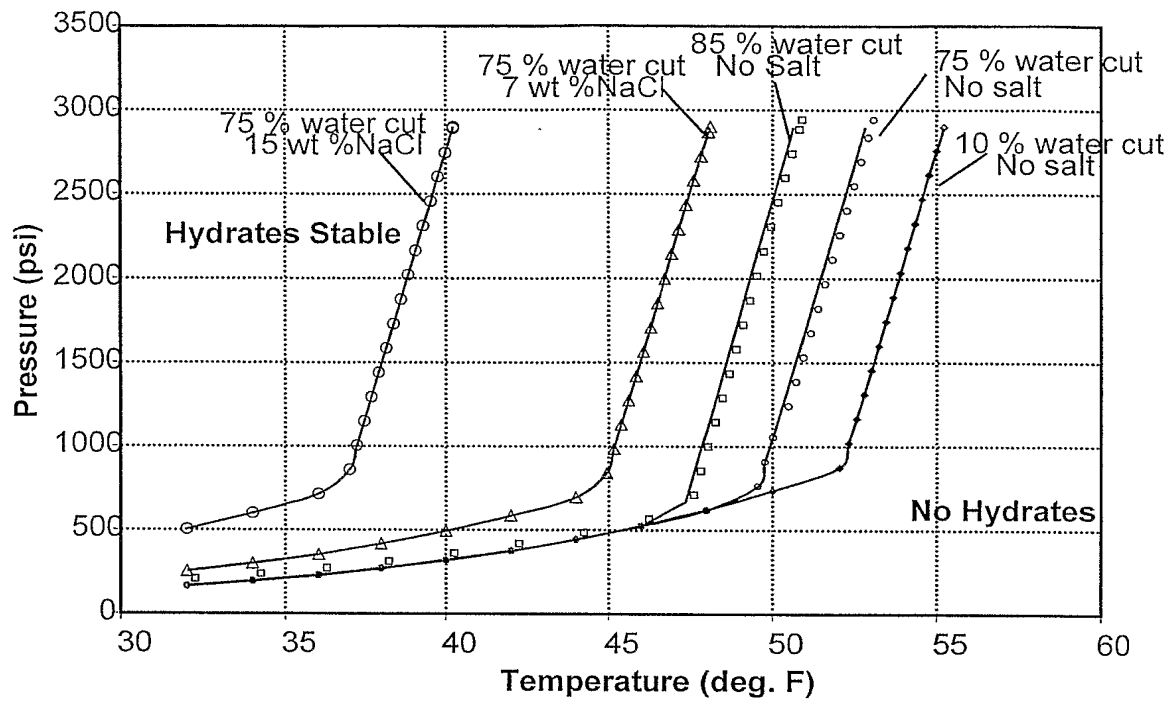


FIG. 1

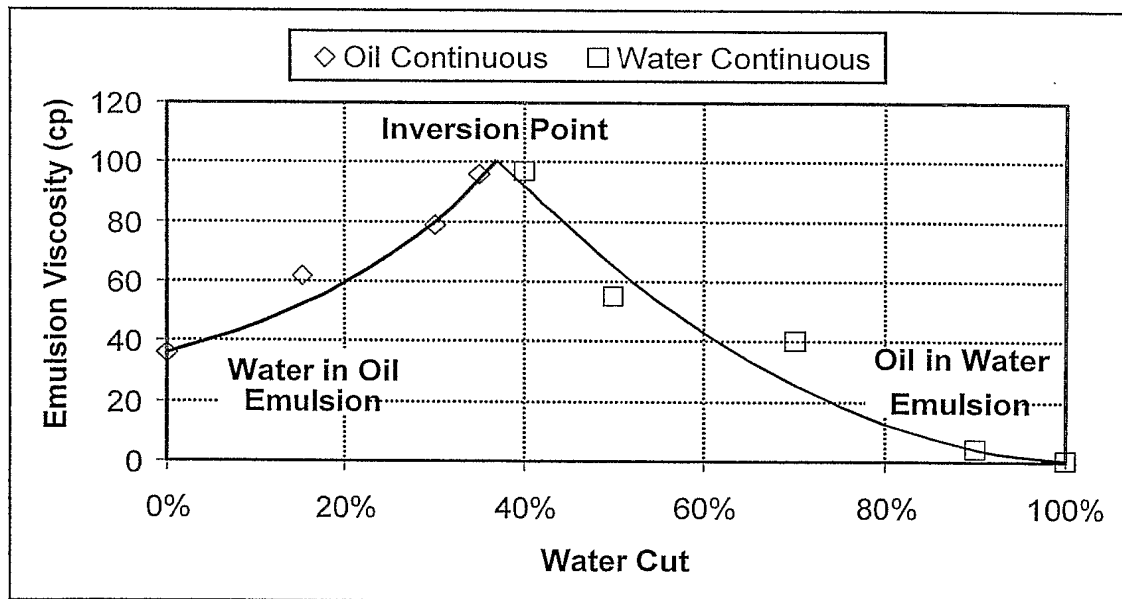


FIG. 2

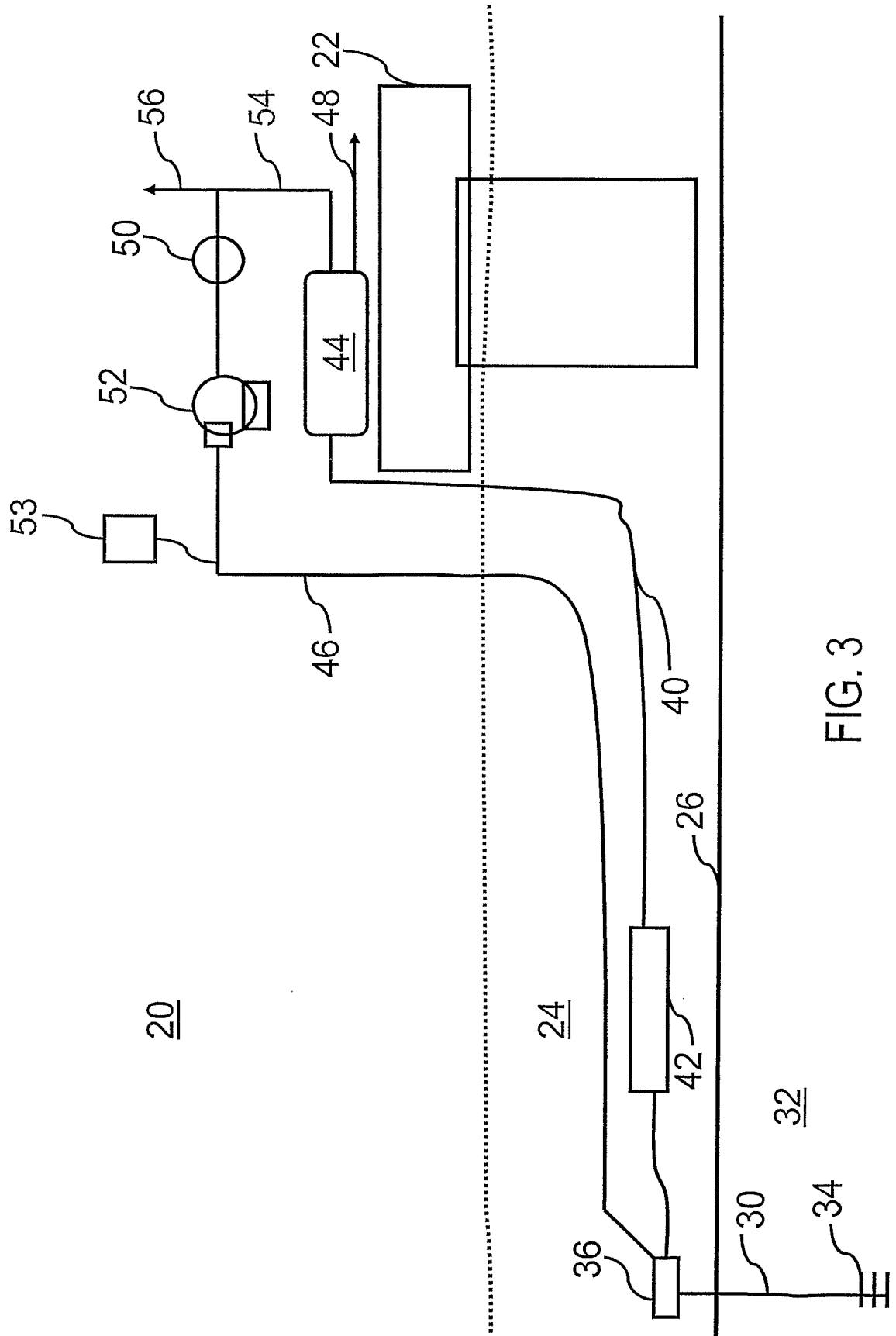


FIG. 3

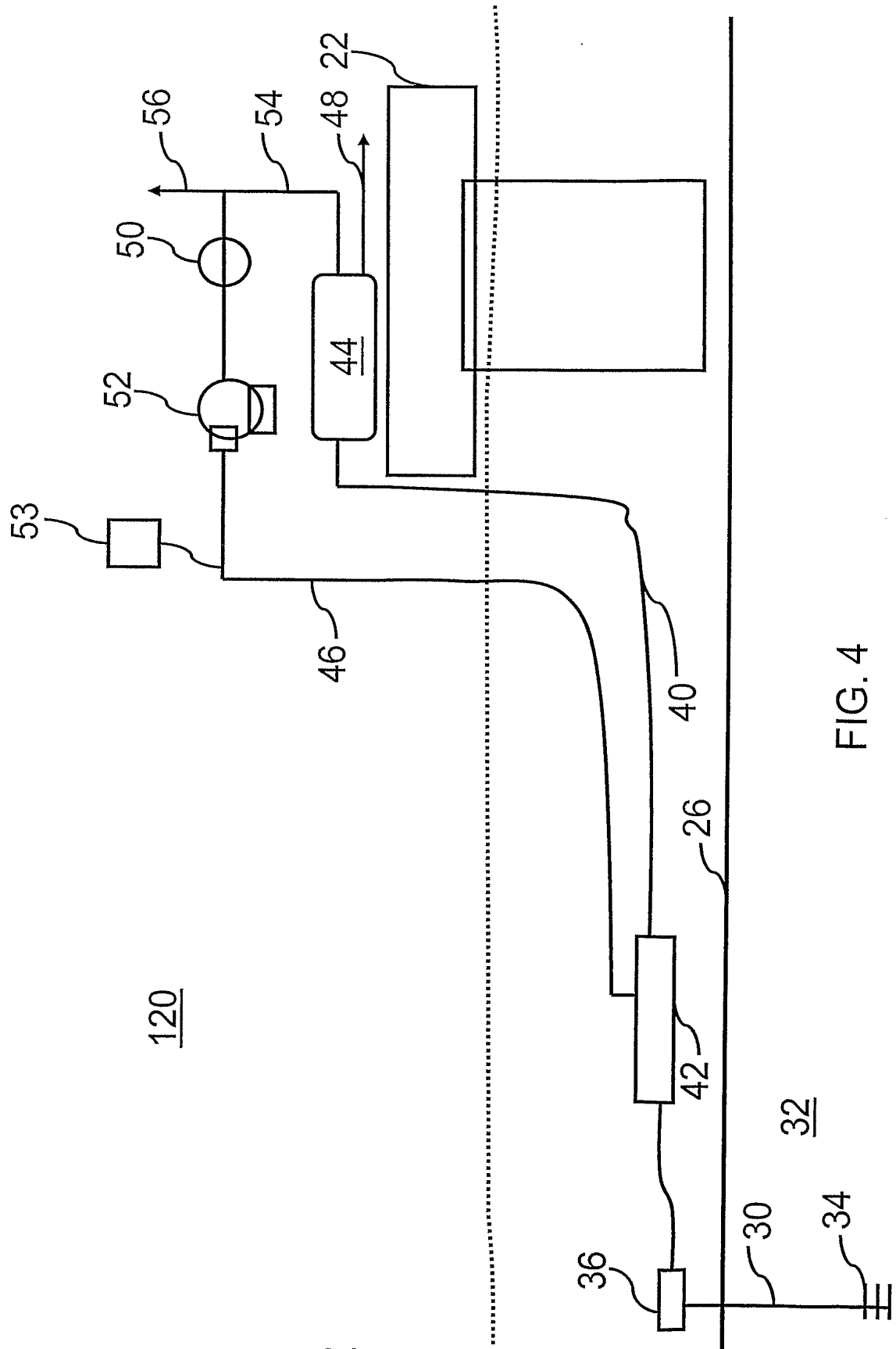


FIG. 4

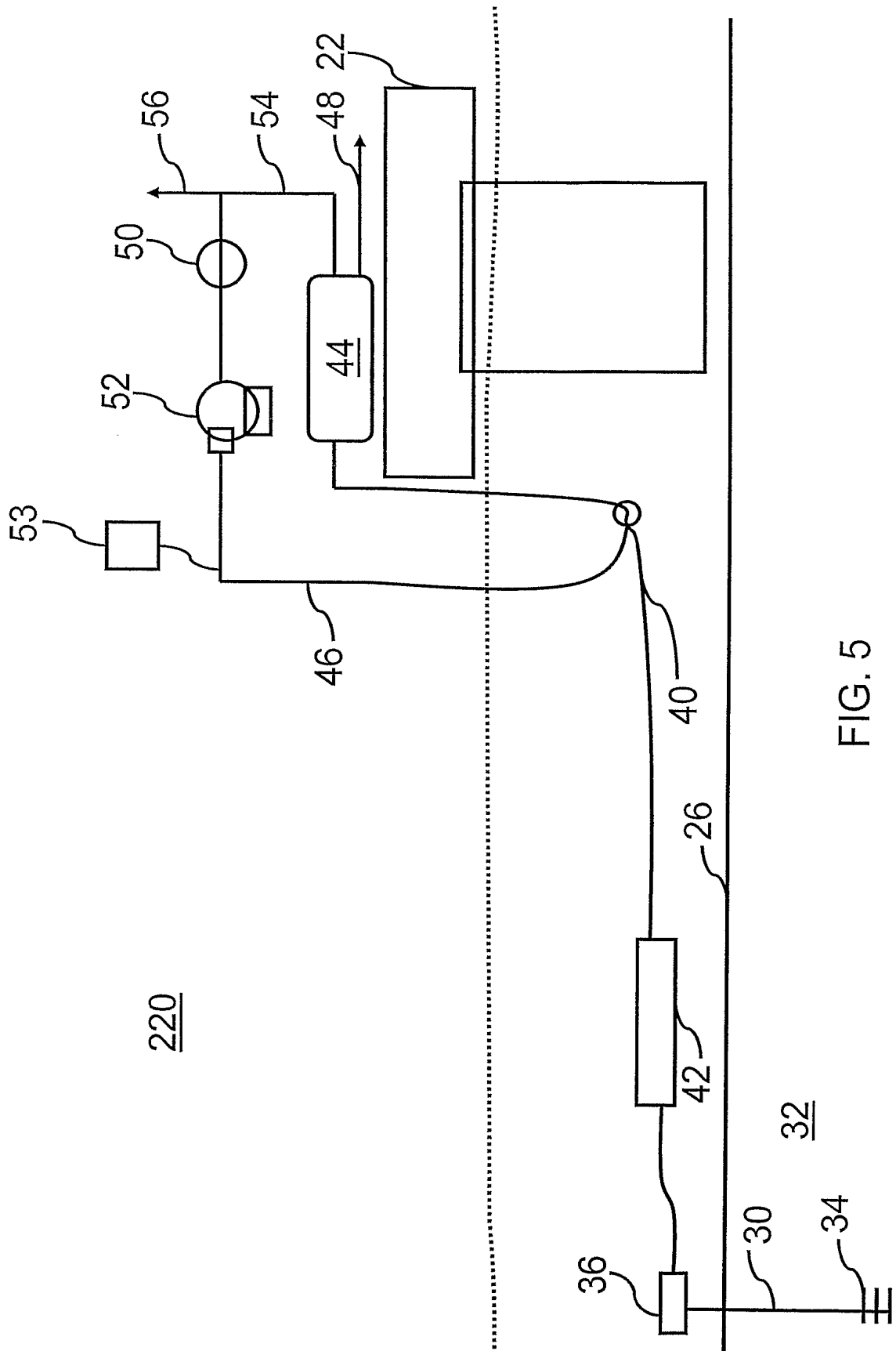


FIG. 5

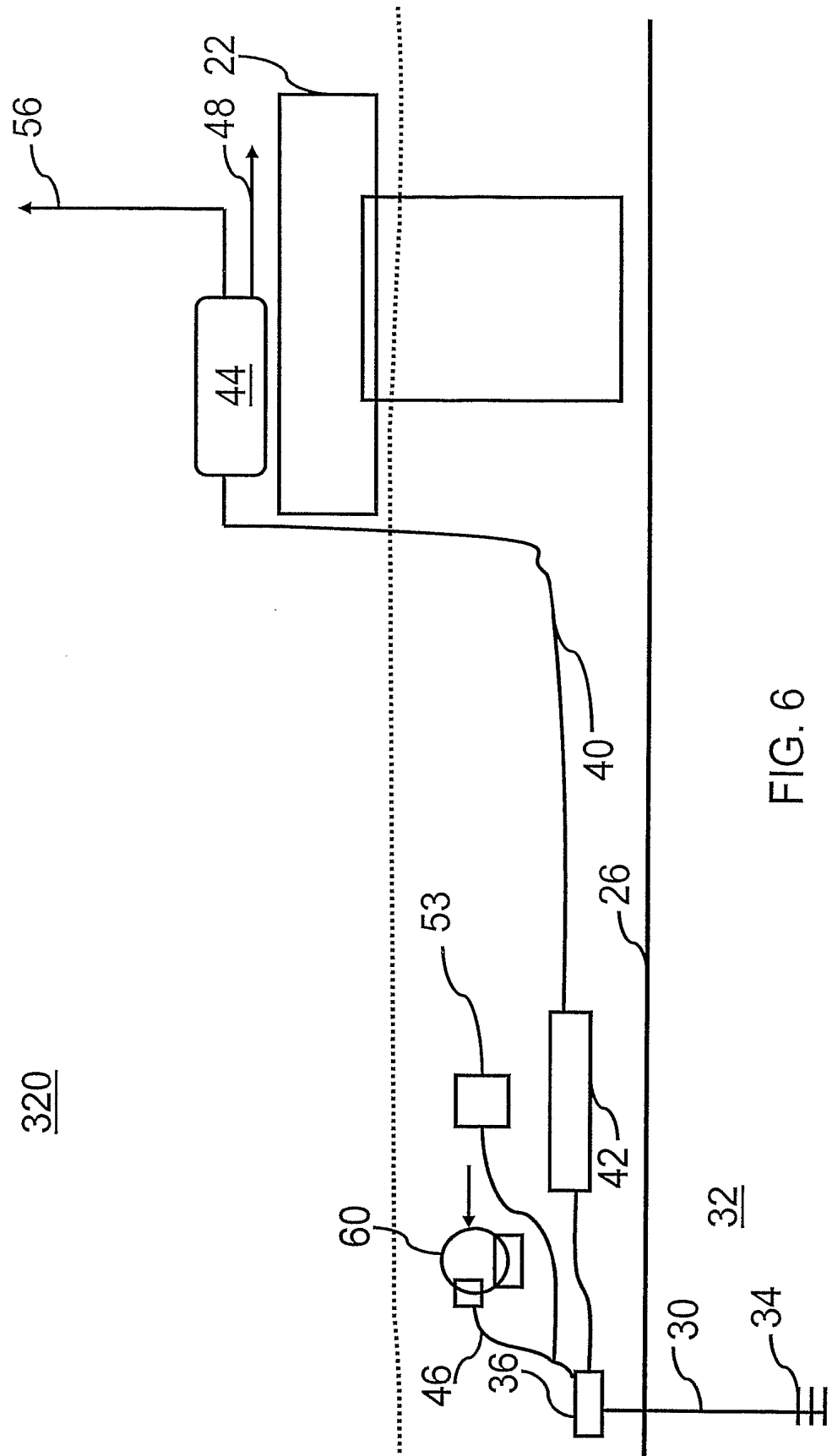


FIG. 6

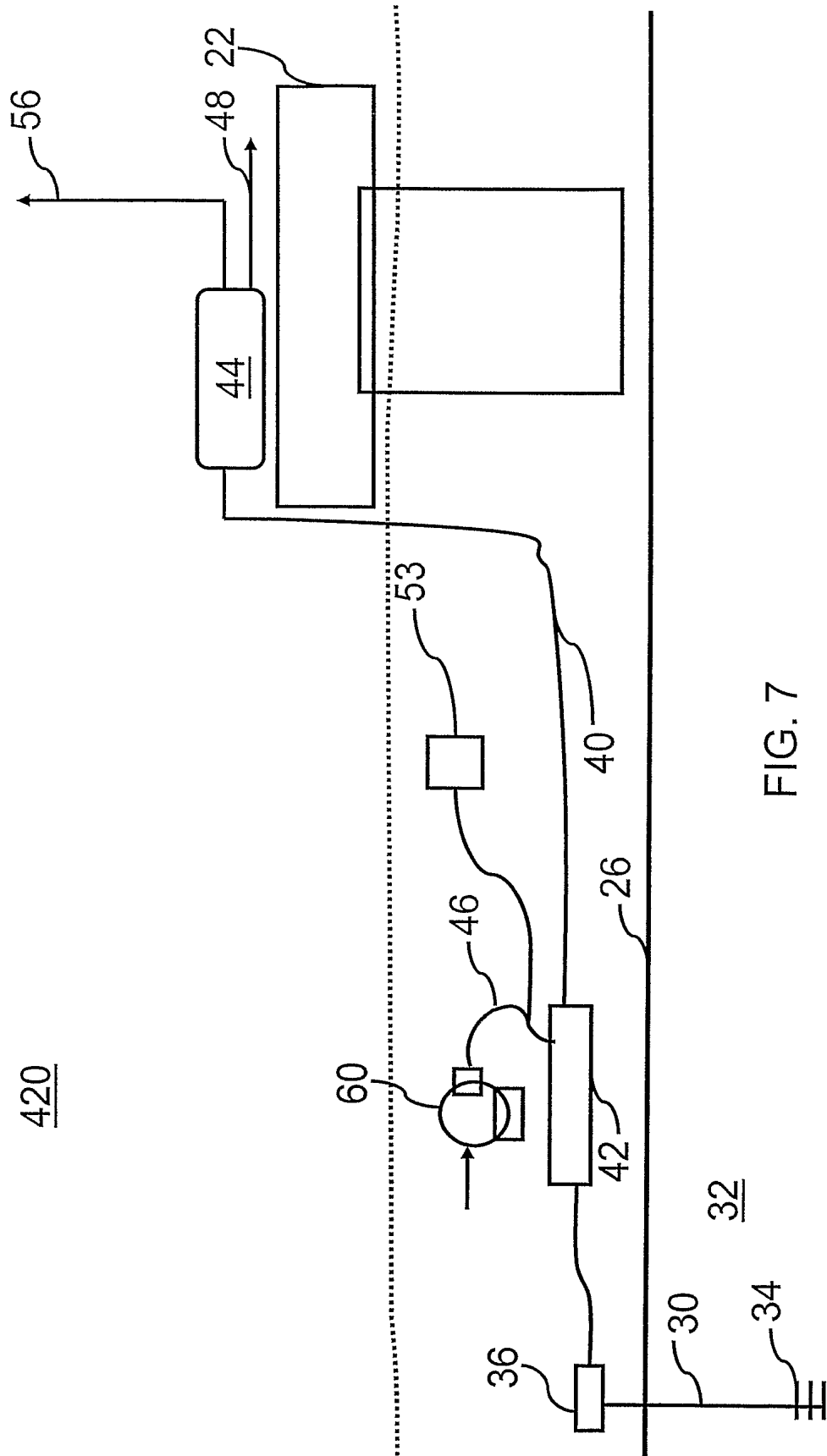


FIG. 7



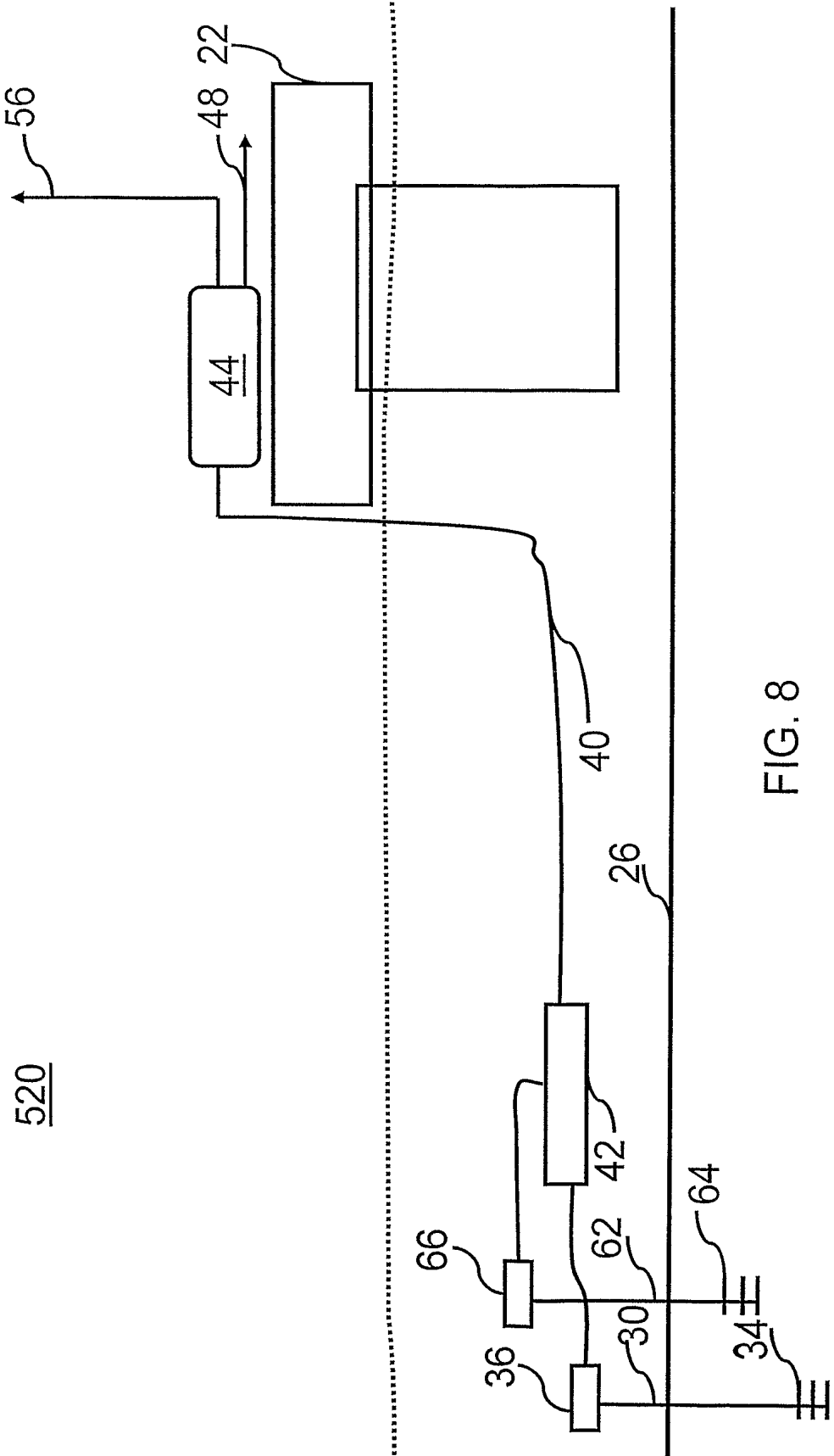


FIG. 8



**(10) International Publication Number**  
**WO 2005/058450 A3**

**(57) Abstract:** The present invention includes a method for inhibiting hydrate formation blockage in a flow line [40] used to transport hydrocarbon containing fluids. Water is added [46] to a hydrocarbon containing fluid to produce a water cut enhanced hydrocarbon containing fluid [40]. Salt may be added to the hydrocarbon containing fluids as well. Hydrate formation blockage is inhibited from forming within the flow line by the addition of the water and/or the salt. A salt dispenser [53] may also be included which is used to increase the salinity of the hydrocarbon containing fluid. The system may further include a water separator [44] to separate hydrocarbons [48] from water [54] which receives fluids from the flow line. The flow line [40], water separator [44] and water injection conduit [46] may cooperate to form a loop wherein water from the flow line may be separated by the water separator and a portion of the separated water [54] is delivered back to the water injection conduit [46] to be reinjected into the flow line [40].

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/42345

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C07C 7/20; F17D 1/05

US CL : 585/15, 950; 137/3, 13; 95/153

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 585/15, 950; 137/3, 13; 95/153

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EAST search terms: hydrate, flow, pipe, pipeline, emulsion

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,491,269 A (COLLE et al) 13 February 1996 (13.02.1996), column 2, lines 22-33, column 2, line 62 to column 3, line 19.	1-19
Y	US 6,222,083 B1 (COLLE) 24 April 2001 (24.04.2001), column 4, lines 23-37.	1-19
Y	US 6,194,622 B1 (PEIFFER et al) 27 February 2001 (27.02.2001), claims 1 and 18.	1-19
A	UA 6,451,892 B1 (BAKEEV et al) 17 September 2002 (17.09.2002), column 1, line 15 to column 2, line 12.	1-19
A	US 6,281,274 B1 (BAKEEV et al) 28 August 2001 (28.08.2001), column 1, line 8 to column 2, line 7.	1-19
A	US 6,080,704 A (HALLIDAY et al) 27 June 2000 (27.06.2000), column 1, line 6 to column 2, line 7.	1-19

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"E" earlier application or patent published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

06 October 2005 (06.10.2005)

Date of mailing of the international search report

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